Age-Invariant Face Recognition Using Trigonometric Central Features

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Abstract

Many facial recognition systems must fail because of many influences such as lighting, changes in composition, expression and aging in the face. But the effects of facial aging are the main problem that many algorithms face with precision. Accordingly, this work provides a model based on the extraction of a number of trigonometric features. The proposed model includes three areas connecting and surrounding the main facial features. In addition, aging is recognized by calculating the trigonometric zones extracted. The system compares the query face with the database. Then, the query image is extracted from the original face image. Next, the performance of the proposed model is compared with some of the latest facial recognition techniques. Facial recognition systems in different stages of life prove that the proposed facial recognition system gives enhanced accuracy of 99.80% with very low FAR level of 0.0001.

Keywords

age-invariant, model, triangles features, trigonometric features, ageing, FG-NET.

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1. Introduction

The identification of faces at various stages of age is especially important at present because of the security events associated with the escape of a large number of criminals from one country to another. Therefore, it is necessary to look for ways to detect these fugitives after a long time. The system of identifying high-resolution faces must be developed. Because aging increases lower recognition rates by 5% [1], it is normal to have variable features in the future. Therefore, the face recognition system must provide the necessary authentication to identify people regardless of their age at different stages of life. Due to the inevitability of aging, facial features change dramatically, resulting in significant changes due to age factor. Thus, the importance of this system to know which face has been changed. The accuracy of facial recognition is usually limited by large differences within the mass resulting from factors such as morphology, lighting, expression and age [2]. Therefore, most of the current work on facial recognition focuses on compensating for differences that lead to deterioration of facial recognition performance. However, different stages of age have not received enough attention compared to the sources of other differences such as morphology, illumination and expression [3].

With the development of technologies and systems, face recognition system recognizes people at different stages of life because of differences in some details in features from one stage to the next [4], and we will learn about the models and methods used to solve this problem. We therefore propose a new model that addresses each of the shortcomings in an effective manner. The proposed model, in terms of classification accuracy, is compared with other methods used in the FGNE database contains 1002 facial images of 82 people aged from 0 to 69. This is one of the most widely used data which has the largest age group [5].

2. The proposed model

In this proposed model, we will work on getting the focal points of the face that represent the main points of this model. We will also build three main triangles of the face area. Then connect the distinctive points of the face to obtain three triangles in the areas of the least change through the age and then

derive a set of sports relationships to get the result of each face image through the center of the face and center of the eyes and center nose and center of the mouth.

2.1. Details of proposed model work

The proposed system extracts five essential features of the face and then begins facial recognition.

The system contains the main stages:

- Face Detection
- Extract features
- Face recognition

The stages of the system as in Fig. 1:

First: an input image is presented to the proposed system represented in Fig. 2 as an example of the input image.

Second: Resize the image; the image size is changed to 224×224 pixels for further processing.

Third: The face is detected, and the central point of the face is identified as a feature of the main face.

Fourth: The two eyes are detected, and the focal points of the eyes are identified as two main features.

Fifth: The nose is detected, and the central point of the nose is determined.

Sixth: The lips are detected, and the central point of the lips is determined.

Seventh: The focal points are connected to form three main triangles.

Eighth: The parameters of the triangles in the input image are calculated with the rest of the images stored in the base and compared.

Ninth: The inserted image is extracted with the closest results to get the recognition.

2.2. Detailed design of the proposed model

In this proposed model, we will work to get the focal points of the face representing the main points of this model. We will also build three major triangles in the face area. Then we connect the distinctive points of the face to get three triangles, and then create a set of sports relationships to get the result of each face image through the center of the face, center of the eyes, center of the nose and center of the mouth, which we consider to be the less altered areas (due to age) of the face.

Fig. 1. Plan of work stages of the system.

Fig. 2. Example of input image.

2.3. Method used

In our proposed model, we have used Matlab R2018a. An input image is presented to the system that

represents Fig. 3 as an example to enter the image. Image resizing: When you render the method using an input image, the image is resized to 224×224 pixels for further processing.

The eyes are then exposed and the nose and lips are extracted using a formula focusing on the distance between the eyes [6]. For extraction purposes, 5 points are extracted on the face (center of the left eye, center of the right eye, center of the face, center of the nose, center of the lips).

Eye detection: To extract the eyes from the human face, there is a need for dark pixels on the face. Because eyes are different from skin color, the use of color space and color separation can be a good way to identify eyes [7].

The eye area is then determined, and the eye is extracted from the image and the nose and lips discovery process is based on the distance between the eyes. The nose and lips are extracted by assuming that they are located on a certain proportion of the distance between the eyes.

First: Pass the test image to get the central points as follows:

The central point of the face: Fig. 4.

The face is divided from the top point to the bottom point until we get the X axis and then from the right

Fig. 3. System extraction 5 facial features.

side to the left of the face to get the Y axis. Then, we get the intersection between the X axis and the Y axis.

Fig. 4 shows the axes adopted to obtain the center points.

Through the following relationship: Eq. (1).

$$X_{Center} = (x1 + x2)/2$$

$$Y_{Center} = (y1 + y2)/2$$

2.3.1. The central points of the eyes

We extract the eye points through the average starting and ending points as shown in Fig. 5, through Equation number 1.

The central nasal point is extracted in the same relationship as in Fig. 6.

Through Equation number 1, the central point of the mouth is extracted in the same way as in Fig. 7.

Through Equation number 1, the central point of the mouth is extracted in the same way as in Fig. 7. Extract all axial points of the face as shown in Fig. 8.

The process of extracting all the focal points begins by extracting the center point of the face at the intersection of X and Y as explained above, and the rest of the central points are obtained with the average start and end of each part of the face.

Initially, several test images will be entered into the proposed system in MATLABR2018a, and the number of images is 30 images for six persons then all test images are collected. Coordinates are retrieved for a

set of five distinct facial points, at which points coordinates are linked to Matlab.

The coordinates of the five face feature points selected will be moved to the system. The return coordinates of facial features will be used to form three different zones surrounding the main facial features (eye center, nose center, center of mouth, and center of the face). Parameters of trigonometric regions are then calculated through mathematical equations to compare the main image and test images to find a similar image in terms of results.

The first triangle is represented in Fig. 9: the distance between the center of the eyes and the center of the face.

The second triangle, represented in Fig. 10, covers the distance between the center of the eyes and the center of the nose.

The third triangle represented in Fig. 11 covers the distance between the center of the eyes and the center of the mouth.

2.4. Extract features

Fig. 12 Illustrates the three trigonometric zones adopted in our proposed model.

The first triangle is between the center of the eyes, the center of the face and the second triangle between the center of the eyes, the center of the nose and the third triangle between the center of the eyes and the center of the mouth.

Fig. 4. a)The location of axes.b)The central point of the face

Fig. 5. The focal points of the eyes.

2.5. Calculate triangles parameters

Five coordinates are extracted from the features of the face, and a distance is calculated between each

Fig. 6. The central point of the nose.

Fig. 7. The central point of the mouth.

Fig. 8. Facial feature points used in the proposed model.

three focal points of the face feature for the calculation of the perimeter and regions of each triangle, then we collect the triangular regions of each image to form one result and compare them with the rest of the results.

We consider triangles to be similar when achieving the following equation:

Fig. 9. Triangle 1.

Fig. 11. Triangle 3.

Fig. 10. Triangle 2.

Fig. 12. Triangles collection.

$$T_q = T_r \quad \text{Eq.2}$$

Where q is a triangle of the query image and r is a triangle of the recognition image.

Triangles are collected by the following equation:

$$T_q = T_a(T_b + T_c)^2 \quad \text{Eq.3}$$

$$T_r = T_a(T_b + T_c)^2 \quad \text{Eq.4}$$

Where triangle T_a , T_b , T_c is shown in Figs. 9–11.

3. Results and tests

The system testing process begins with four stages:

3.1. First stage

By entering the main face which will be the queries and compare it with other aspects of the base.

Fig.13 is the identification system interface.

When you run the system and click on the selection of the query face the system asks to enter the query face of the file in it and for further processing the

Fig. 13. The main interface of the proposed system.

image size is converted to 224×224 pixels.(see Figs.14–18)

After the previous steps are selected points of the face, where three triangles are formed through five central points defined in:

The first triangle: center of the right eye, center of the left eye, center of the face.

Triangle II: Center of the right eye, center of the left eye, center of the nose.

Third triangle: center of the right eye, center of the left eye, center of the lips.

The system measures the basic features of the query face through trigonometric features and maintains the result to be compared with the closest results in the database.

3.2. Second stage

The system requests the images stored in the rule and the process of discovering the trigonometric features in the same way we presented in the first stage and saves all the results to be compared with the face of the query.

3.3. Third stage

After the system maintains the results from the first stage and the second stage, the results of the first phase are compared with the results of the second stage.

Fig. 14. The main interface of the proposed system with the query face and aspects of the rule.

3.4. Fourth stage

It is the final stage of the system to take out the query face with the face-like image in the database after discovering the trigonometric features of both images.

Results and tests show that the proposed system is not effective in small age groups. Many of the identification systems have the same problem, but the main features of the less variable face with age make it better than other systems in terms of recognition rates.

The characteristics of children are compared to the characteristics of other groups closer to each other through the results of features for ages 0–6 years, which is difficult for systems to discover it is in most countries of the world take a picture of each child and during each year to renew a passport or similar to reduce the failure Recognition process.

The rate of recognition of the system for children and the rest of the age groups within one year is 100%, but

the process of failure begins after a long time between the time of the original picture and the current picture.

In testing the system in adult age groups, the system appears to have a good response rate for this group through its experience on many adult images.

We find that the system identified an adult by a difference of 10 years between the original picture and the current picture of the person.

The third age group, the age group, which suffers most identification systems in finding the face of recognition, we find through the results the success of the system in recognition and a good time difference between the original image and the current image of the person is 20 years.

From the results, we can see that the proposed model can work better in terms of recognition rates.

When comparing our model, which uses age-sensitive features to identify the face, we find that we have improved in terms of recognition rate. However, our

Fig. 15. The main interface of the proposed system with the query face and the similar face.

Fig. 16. Comparison of children's faces.

approach can be applied to further improve its performance. This means that our proposed approach is effective for recognizing age.

The importance of this model lies in its ability to show the association of the main facial features with each other over the ages.

Fig. 17. Comparison between the faces of adults.

Fig. 18. Compared with the face of aging.

This system is ideal for high performance, low-latency applications to reduce the number of features detected from 83 [8] to 5 basic features.

4. Evaluation and comparison

Our experience in using some images in the FGNET aging database was adopted to compare the proposed model to determine age with other methods.

The proposed system in this part has been applied and tested on MATLAB R2018a and on the same system with the following specifications: Pentium CPU 3.4 GHz, 4.00 GB RAM and X64-based processor.

To assess the ability of the model to identify at different stages of life, we have to compare it with

some relevant methods in terms of recognition, accuracy and performance. We can see that the proposed system outperforms LBP [1] and Gabor [9] with a large margin, so it is more computationally efficient, faster and more efficient.

However, the system has been tested on three sub-groups of FG-NET representing the stages of childhood, adolescence and adult.

Our system outperformed Park [8] in terms of verification accuracy and error rates; however, the processing time was 82% less than the reported processing time reported by Park.

The system was developed to address the mistakes of others and to maintain the appropriate classification for all age groups. Moreover, the performance of the

system in verification mode was constant in all age groups; I think it is a promising system [10,11].

5. Research contribution

Using trigonometric features to reduce face recognition problems at different stages of age get the highest accuracy of facial recognition, and speed in performance.

6. Conclusion and prospects

In this study, we proposed a new approach to face recognition at different stages of life by focusing on the five basic facial features and the least change over a lifetime. By comparing these face-recognition methods to facial images with age differences, our model can improve recognition significantly.

The appearance of the face changes gradually and this change may affect all human faces. The quality of the image that plays a key role in not recognizing when there is a defect in one or both images.

Quality can deteriorate due to poor lighting problems, poor focus, or poor image cropping. These effects reduce the degree of similarity. Good design reduces errors related to photography.

The challenge for research is the availability of only a limited number of training samples. So, in our experience, we simply divide images into three age groups. However, the results of the experiment showed the effectiveness of the proposed model. In our future research, more training samples will be collected at different ages, so learning from recruitment functions and projection matrices can be more accurate. In addition, we will address the image quality problem, and other types of features will be used.

The system was tested on three subgroups of FG-NET representing the stages of childhood, adolescence and adult. The system maintained a fairly good rating for its disadvantage in small age groups.

That the proposed system gave new and good features:

- Ability to recognize different stages of life.
- Ability to recognize with different facial expressions is not affected by the facial expressions because the central points.
- Ability to recognize in situations of disguise.
- Ability to identify with people who have performed cosmetic operations.

- Ability to recognize with different facial appearance in terms of (mustaches, eyebrows, hair) because it is not affected by them.

In the near future, we will modify the proposed model to keep pace with the evolutionary age. We will combine many of the recognition features that we found to be useful in adding them to our proposed model, the point from the bottom of the ear to the chin position to calculate the length of the jaw.

The eye cavity also plays a major role in discovering the person's race. Most Asians have similar eyes and are different from other people in Europe.

You can add a different color of black skin from white, the system to ignore the white faces and can be obtained in this case a quick response and a record time in the recognition rates of the system.

There are many differences between natural people in the structure of the nose, which indicates a higher rate of recognition.

There are many people who have a scar or a mole ... etc. This is the complete sign of ignoring many people in the identification base so we will seek to put this distinctive mark of natural people (who did not perform beautification) in our future knowledge to search for these people, High accuracy in recognition and faster response time.

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